

REVISION OF THE RECENT SPECIES OF THE FAMILY CLAVAGELLIDAE (MOLLUSCA, BIVALVIA)

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SUMMARY

The recent species of the family Clavagellidae are revised and 17 species and sub-species are recognised in three genera. A new subgenus *Humphreyia* (*Nipponoclava*) subgen. nov. is introduced and the inter-relationships and zoogeography of the various species discussed.

INTRODUCTION

Following the revision of the Australian species of the family Clavagellidae (B. J. Smith, 1971), reference collections of several of the larger natural history museums were examined in order to attempt to assess the status of all the recent species of this family. The family was revised by L. A. Smith (1962) but no reasons were given for his placement of species or for his synonymies and no evidence given that he had examined type material or attempted to apply nomenclatural procedure. The value of this work rather lay in the cataloguing of the described species.

The watering-pot shells (Clavagellidae) are very rarely taken alive, most of the specimens in collections being dead shells. Because they either live embedded in, or cemented on to, a hard substratum, or live buried in a substratum of variable consistency, the shape of the shells are extremely variable in form. This had led, in the past, to many species names being introduced into the literature for the many different shell forms available (Chenu, 1843; Reeve 1860, 1873).

The present study is an attempt to rationalize the present knowledge of the recent species of the family Clavagellidae by a critical examination of all available types, together with as large a sample of material of all species as possible. Because of the small amount of live collected material available, coupled with the general lack of useful anatomical characters at the specific level in bivalve taxonomy, only shell structure has been used to delineate species characters. Only recent species have been considered at this stage because of the paucity and patchiness of the fossil record for most of the species groups. However notice has been taken of fossil taxa in so far as they effect the nomenclature of the recent taxa.

The following abbreviations are used: AM – Australian Museum, Sydney; BM(NH) – British Museum (Natural History); MCZ – Museum of Comparative Zoology, Harvard University; M.N.G. – Museum d'Histoire Naturelle, Geneva; N.M. – Natal Museum, Durban, South Africa; N.M.V. – National Museum of Victoria, Melbourne; P.A.S. –

Philadelphia Academy of Science, Philadelphia; SAM — South Australian Museum, Adelaide; T.M. — Tasmanian Museum, Hobart; U.S.N.M. — United States National Museum, Smithsonian Institution, Washington D.C.; W.A.M. — Western Australian Museum, Perth.

SYSTEMATIC SECTION

Family CLAVAGELLIDAE Orbigny, 1844 (= ASPERGILLIDAE Gray, 1858)

The three genera are characterized by the form of the valves, whether one or both are incorporated in the structure of the tube and the size and significance of the valves relative to the anterior end of the tube containing the body of the animal. Subgeneric grouping within the genera are determined by the general form of the tube and anterior end or disc. These latter factors are to some extent related to the habitats occupied by the various species.

Genus *Clavagella* Lamarck, 1818

Clavagella Lamarck, 1818, *H. N. Anim. sans Vert.*, 5: 430. Type species:

Clavagella echinata Lamarck 1818 (S.D.; Children, 1823).

Synonymy: *Fistulana* Lamarck 1818, *H. N. Anim. sans Vert.*, 5: 432 (no type species found).

One valve fused with the tube, the other remaining free inside the anterior cavity, both adductors persistent in the adult.

A large number of fossil species belonging to this genus were described by Lamarck (1818) from the Paris Basin and other European localities. Members of this genus are regarded as being the most primitive species in the family, closer to the more typical bivalve stock from which the family arose, because of the persistence in the adult of both the shell adductor muscles.

Subgenus *Clavagella* s.s.

Tube free or attached by anterior end only, siphonal end simple, anterior portion with simple spine-like tubules.

Clavagella (Clavagella) torresi Smith, 1885

(Fig. 1-2)

Clavagella torresi Smith, 1885. "Challenger" Reports. *Lamellibranchiata*, 13, 28, pl. 8, figs. 1a — b.

DIAGNOSIS: Tube with one or two longitudinal ridges, not constricted at junction with anterior swollen portion, hinge near anterior end of fixed valve; tubules mainly from side of anterior portion of tube opposite hinge and at anterior end.

TYPE MATERIAL: Holotype in British Museum BM(NH) 87.2.9.2379. Length 17 mm.

TYPE LOCALITY: Torres Strait, North Queensland.

DISTRIBUTION: (Map 1.) Torres Strait and Gulf of Carpentaria, North Queensland to Lindeman Island, Central Queensland and Singapore.

MATERIAL EXAMINED: See Smith (1971) for Australian material. Holotype. New Harbour, Singapore, 13 m. G. Wilkins Colln. BM(NH).

REMARKS: This species is the larger of the two species of *Clavagella (sensu stricto)* still found living. It is separated from *C. (C.) multangularis* by its larger size, the presence of only one or two longitudinal ridges on the tube instead of six or more, and by the absence of a constriction between the tube and the anterior swollen portion of the shell. The very few specimens so far collected of this species indicate a wholly tropical distribution in shallow waters of the Malaysian-Indonesian-Northern Australian region. Thus far no live material has been collected but it can be considered a recent species from the "fresh" condition of the type and one or two other specimens taken from Queensland waters.

Clavagella (Clavagella) multangularis (Tate, 1887)

(Fig. 3.)

Aspergillum multangulare Tate, 1887, *Trans. R. Soc. S. Aust.*, 9: 64, pl. 4, figs 4a — b.
For synonymy see Smith (1971).

DIAGNOSIS: Tube small, multi-angular in section, with 6 or more longitudinal ridges and slightly constricted at junction with anterior swollen portion; hinge forming apex of anterior portion, tubules mainly from anterior end, total length less than 3 cm.

For details of type material and distributions see Smith (1971) and Map 1.

REMARKS: This species differs from *C.(C.) torresi* by its smaller size, the possession of 6 or more longitudinal ridges on the tube and the constriction between the tube and anterior swollen portion. It is found only in the cool temperate waters of Southern Australia and has been taken over most of the continental shelf from 2-3 m to 250 m.

It is found living attached to hard surfaces such as rocks or shells, but it can also be collected in situations where it appears to be free-living partially embedded in the substratum. A common habitat is on valves of dead bivalves and a number have been taken from between the large spines of *Spondylus tenellus*. Despite it being a fairly common shell in several localities in Victorian and South Australian waters, very few have been collected alive and none have yet become available for anatomical study.

Subgenus *Bryopa* Gray 1847

Bryopa Gray, 1840. *Syn. Cont. Brit. Mus.*, 42: 150 (n.n.); 1847. *Proc. Zool Soc. Lond.*, 15: 188.
Type species: *Clavagella aperta* Sowerby, 1823 (O.D.).

Tube and anterior end embedded in rock; siphonal end often expanded in a series of plaited ruffles or with complex longitudinal ridges; anterior end with small holes and short tubules opposite free valve.

The animals are usually found in calcareous rock and inhabit holes either entirely constructed or considerably enlarged and modified by the animals. These holes are lined by the calcareous tube of the animal.

Clavagella (Bryopa) aperta aperta (Sowerby, 1823)

(Fig. 4-5)

- Clavagella aperta*, Sowerby, 1823, *Genera of Recent and Fossil Shells*, figs. 1-4.
Clavagella sicula, Chiaja, 1830. *Mem. An. s. vert. Napoli*, Tab. pro 5 & 6, pl. 83.
Clavagella balanorum, Scacchi, 1842. *Philippi. Enum. Moll. Sic.*, 2. 1: 1, pl. 13, figs. 2a, b, c.
Clavagella aperta, Chenu, 1843. *Illus. Conch.*, 1, *Clavagella*: 4, pl. 1, figs. 3 & 6, pl. 3, fig. 9.
Clavagella balanorum, Chenu, 1843. *Illus. Conch.*, 1, *Clavagella*: 4, pl. 1, fig. 7.
Bryopa aperta, Gray, 1858. *Proc. Zool. Soc. Lond.*, 26: 314.
Clavagella balanorum, Reeve, 1873. *Conch. Icon.*, 18, *Clavagella* pl. 1, figs. 1a, b, c.
Clavagella aperta, Reeve, 1873. *Conch. Icon.*, 18, *Clavagella* pl. 1, figs. 2a, b, c.
Clavagella philippiana, Reeve, 1873. *Conch. Icon.*, 18, *Clavagella*, pl. 1, fig. 3.

DIAGNOSIS: Species large with short wide tube, oval in section, with widely reflected lip, sometimes with a series of such lips forming a tube with plaited ruffles. Tube occasionally with two slight longitudinal constrictions. Anterior chamber enclosed in rock but completely lined and perforated in area opposite the fused valve. Free valve triangular to ovoid with hinge and ligament posteriorly.

TYPE MATERIAL: Holotype of *C. aperta* is in the British Museum BM(NH) 1950.10.16.2. None of the type specimens of *C. balanorum*, *C. philippiana* or *C. sicula* could be located in any of the museums where enquiries were made. No overall measurement can be given for the holotype as the specimen is embedded in a large block of calcareous rock. Approximate diameter of the expanded top of the tube is 25 mm.

TYPE LOCALITY: No locality is given, either in the original description or with the type specimen. However most subsequent references give the locality as Malta in the Mediterranean. The type locality is here restricted to Malta.

DISTRIBUTION: (Map 1.) Malta and Sicily in the Mediterranean, and possibly the northern part of the Red Sea.

MATERIAL EXAMINED: Malta. C. Wilkins Colln., 1 spec., BM(NH); C. T. Trechmann, 1 spec., BM(NH); H. Cumings, 2 spec., (NMV); Luento Cavallo. Dr. Tams, 1 spec., BM(NH); H. Cumings, 1 spec., BM(NH); Medit. 1 spec., (MNG). Holotype, no loc. BM(NH).

REMARKS: The species *C.(C.) aperta* is characterized by a wide tube, oval in section, without longitudinal ribbing but with a widely reflected lip which can be duplicated to form plaited ruffles. Two subspecies are here recognized. The nominate subspecies has a large tube with a maximum



diameter of 15 mm or more (many specimens over 25 mm), with a wide reflected lip. It is known only from the central region of the Mediterranean around Malta and southern Italy, except for one record from the northern part of the Red Sea which is possibly referable to this species (Soliman, 1971). This will be discussed in more detail below.

The other subspecies, *Clavagella (Clavagella) aperta minima* described below, is smaller in size with a correspondingly smaller lip and is only known from Mauritius in the Indian Ocean.

The material described by Soliman (1971) from coral reefs around Al-Ghardaga on the north-western coast of the Red Sea just south of the Gulf of Suez at depths ranging from 3-6 feet (1.5-3 m), can be tentatively referred to this species. Soliman described the specimens as boring into coral, with no external tube and only a partial calcareous lining to the cavity in which it lives. However the animal is a typical *Clavagella* with a completely enclosed visceral mass, two large adductor muscles and enclosed, muscular siphons. The free valve is large and approximately triangular in shape with the large posterior adductor muscle scar towards the apex of the triangle. This character is closer to *C.(B.) aperta* than to the other main possible species it could be referred to, *C.(B.) lata*, which has a square free valve (see description below). The main differentiating features between *C.(B.) aperta* and *C.(B.) melitensis* is the nature of the tube. As the Soliman material had no external tube present, no differentiation can be made except regarding size. The size of the Gulf of Suez specimens fall close to the size range of the nominate subspecies of *C.(B.) aperta* and are approaching the upper limit of the size range of *C.(B.) melitensis*. However, examination of complete specimens in situ would be necessary to finally determine the status of this material.

C. sicula Chiaja, 1830, *C. balanarum* Scacchi, 1842 and *C. philippiana* Reeve, 1873 are all included here in the synonymy of this species because, from the descriptions and illustrations available, they fall within the range of variation of this species.

Clavagella (Bryopa) aperta minima (Sowerby, 1889)

(Fig. 6-7)

Clavagella minima, Sowerby, 1889, *J. Linn. Soc. Lond. (Zool.)*, 20 (123): 400, pl. 25, figs. 21, 22.

DIAGNOSIS: Species small with maximum tube diameter about 5-10 mm, tube oval in section with reflected lip, sometimes with plaited ruffles, tube occasionally with two longitudinal constrictions. Anterior chamber enclosed in rock but completely lined and perforated in area opposite the fused valve. Free valve triangular to ovoid.

TYPE MATERIAL: Sowerby mentioned sighting four specimens in his original description. These are in two pairs embedded in two pieces of calcareous rock. Information from the British Museum (Natural History) (S. Whybrow pers. comm.) states that one pair, Reg. No. 1885.9.19.37,38 is apparently the figured specimen and beneath the board bears the pencilled note "Sow. Journ. Linn." plus "Mauritius (Robillard)".

These have been removed from the rock and the larger is here designated as lectotype, BM(NH) 1885.9.19.37. Dimensions: Length of specimen 20 mm.; max. width of tube aperture 6.5 mm.; length of free valve 9.5 mm.

The other specimen of the pair, BM(NH) 1885.9.19.38, and the other pair (Fig. 7) collectively registered BM(NH) 1886.2.10.48 becoming paralectotypes.

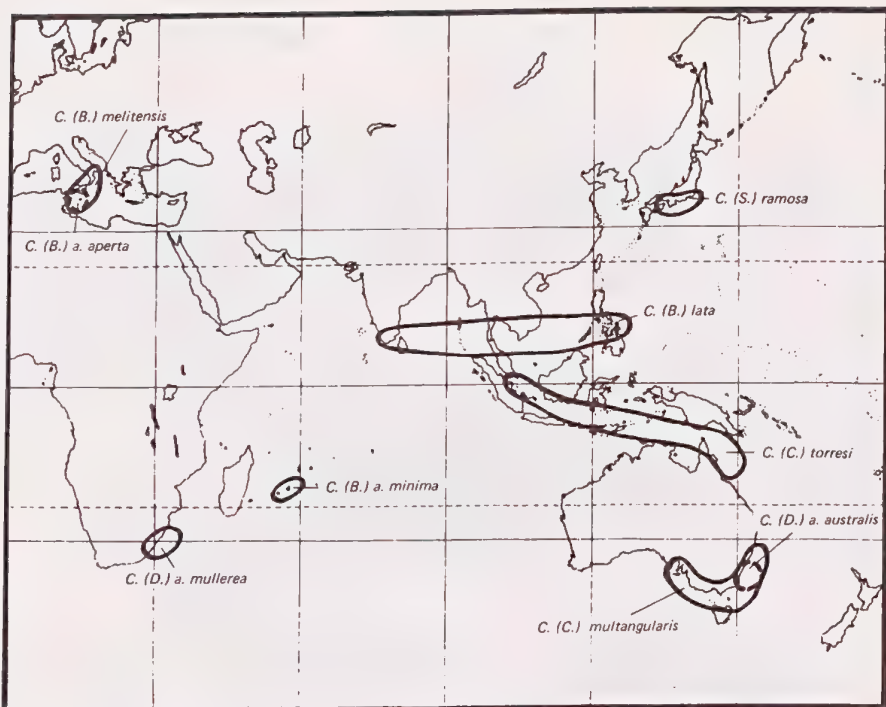
TYPE LOCALITY: Mauritius, Western Indian Ocean in calcareous rock. No more exact locality or ecological data are known.

DISTRIBUTIONS: (Map 1) Only known from the Island of Mauritius.

MATERIAL EXAMINED: Mauritius. Type series BM(NH); Gabriel Colln. (received from Sowerby), 3 spec., (NMV); from Sowerby, 1 spec., (NMV); Gatliff Colln., 2 spec., (NMV); from Robillard, 3 spec., (MNG); from Sowerby, 2 spec., (MNG).

Figures 1-10.

- 1-2. *Clavagella (Clavagella) torresi*, holotype, BM(NH) 87.2.9.2379, Torres Strait.
3. *Clavagella (Clavagella) multangularis*, holotype, SAM D133172, Holdsfast Bay, St. Vincents Gulf, South Australia.
4. *Clavagella (Bryopa) aperta aperta*, holotype, BM(NH) Malta.
5. *Clavagella (Bryopa) aperta aperta*, Malta (NMV)
6. *Clavagella (Bryopa) aperta minima*, lectotype, BM(NH) 1885.9.19.37. Mauritius.
7. *Clavagella (Bryopa) aperta minima*, paralectotypes, BM(NH) 1886.2.10.48. Mauritius.
8. *Clavagella (Bryopa) lata*, holotype, BM(NH) 1950.10.16.1. Pacific Ocean.
9. *Clavagella (Bryopa) melitensis*, Malta, BM(NH).
10. *Clavagella (Bryopa) melitensis*, plate 35, figure 5, from Broderip 1835, *Trans. Zool. Soc. Lond.*, 1.



Map 1. Distribution map of recent species and subspecies of the genus *Clavagella* s.l.

REMARKS: Following the brief description of this species by Sowerby in 1889, no further reference to the species can be found. Smith (1962) did not include it in his listing. Also all the specimens discovered in collections can be traced back, either directly or by inference to the famous dealer of Mauritian natural objects, Robillard. No evidence can be found that the species has been discovered since. Confirmation of its distribution will therefore have to await its rediscovery.

This form is considered to be only subspecifically distinct from the nominate subspecies, differing in size, being much smaller, and with a proportionally smaller reflected lip. It differs from the other species of the subgenus *Bryopa* by its small size, the shape and form of the tube and the shape of the free valve.

Clavagella (Bryopa) lata (Broderip, 1834)

(Fig. 8)

Clavagella elongata, Broderip, 1834. *Proc. Zool. Soc. Lond.*, 2: 116. (nomen oblitum).

Clavagella lata, Broderip, 1834. *Proc. Zool. Soc. Lond.*, 2: 116.

Clavagella elongata, Broderip, 1835. *Trans. Zool. Soc. Lond.*, 1: 265, pl. 35, figs. 1-4.

Clavagella lata, Broderip, 1835. *Trans. Zool. Soc. Lond.*, 1: 265, pl. 30, figs. 8-16.

Clavagella elongata, Cheny, 1843. *Illus. Conch.*, 1, *Clavagella*: 4, pl. 1, fig. 4.

Bryopa ? *lata*, Gray, 1858. *Proc. Zool. Soc. Lond.*, 26: 315.

Clavagella lata, Reeve, 1873. *Conch. Icon.*, 18, *Clavagella*, pl. 3, fig. 6.

Clavagella elongata, Reeve, 1873. *Conch. Icon.*, 18, *Clavagella*, pl. 3, fig. 7a, b, c.

Clavagella (Bryopa) lata, Appukuttan, 1974. *J. Malac. Soc. Aust.*, 3(1): 19, pl. 4.

DIAGNOSIS: Shell medium to large; tube short, oval to figure 8 in section, without terminal lip, or plaited ruffles but with growth discontinuities which may give the impression of reduced ruffles. Right valve free in anterior chamber, oval to square with prominent posterior adductor muscle scar.

TYPE MATERIAL: Holotype in the British Museum BM(NH) 1950.10.16.1. Maximum width of free valve 23 mm. The type of *C. elongata* could not be found in any museum.

TYPE LOCALITY: The original type locality is given as Pacific Ocean. However a locality so vague is obviously a product of either grave doubt or complete lack of knowledge as to the exact locality and can therefore be of no value. Following the recent rediscovery of the species by Appukuttan (1974) the type locality is here restricted to the Gulf of Manaar, South East India.

DISTRIBUTION: (Map 1). South western India, and the Philippines, H. Cuming, 1 spec., BM(NH); Manauli Island, Gulf of Manaar, S.E. India, K. K. Appukuttan, 1 spec., (Mus. of Central Marine Fisheries Research Institute at Mandapam Comp, India).

REMARKS: The rediscovery of this species was described by Appukuttan (1974) from the Gulf of Manaar India. The species is distinguished from others in the subgenus by its simple tube without longitudinal ribs, reflected lip or plaited ruffles, and by the shape of the free valve. The free right valve is oval to square in shape and Appukuttan reports the presence of a dorso-posterior wing, a feature only suggested in the type. The insertum scars for the adductor muscles, particularly the posterior one, are deep and prominent.

C. elongata, Broderip, 1834 has page position preference over *C.(B.) lata*. However no type specimen of *C. elongata* could be found and its description is so brief and sketchy as to make its identity doubtful and it is here considered as a nomen oblitum. Smith (1971) tentatively referred *C. elongata* to *Clavagella (Dacosta) australis*. This is now considered a mistake and it should be treated as a nomen oblitum until such times as a recognisable type specimen should turn up.

Clavagella (Bryopa) melitensis (Broderip, 1834)

(Fig. 9-10)

Clavagella melitensis, Broderip, 1834. *Proc. Zool. Soc. Lond.*, 2: 116.

Clavagella melitensis, Broderip, 1834. *Trans. Zool. Soc. Lond.*, 1: 265, pl. 35, figs. 5-8.

Clavagella melitensis, Chenu, 1843. *Illus. Conch.*, 1, *Clavagella*: 4 Pl. 1, fig. 5, pl. 3, figs. 1 & 6.

Clavagella angulata, Philippi, 1844. *Enum. Moll. Siciliae* 2 : 2

Clavagella melitensis, Reeve, 1873. *Conch. Icon.*, 18, *Clavagella*, pl. 2, figs. 5a, b, c, c.

Clavagella laqueata, Reeve, 1873. *Conch. Icon.*, 18, *Clavagella*, pl. 3, fig. 8a, b, c.

DIAGNOSIS: Species medium to large, tube circular with many prominent longitudinal ribs, no reflected lip or plaited ruffles; free valve round to ovoid with weak muscle scars.

TYPE MATERIAL: No type material of either *C. melitensis*, *C. angulata* or *C. laqueata* were found during a search in the British Museum and in several other institutions. However the erection of a neotype is considered unnecessary as the stability of nomenclature is not in danger.

TYPE LOCALITY: Malta in the Mediterranean.

DISTRIBUTION: (Map 1.) Malta and southern Italy.

MATERIAL EXAMINED: Malta, G. Wilkins Colln. 2 spec., BM(NH); 2 spec. BM(NH); G. B. Sowerby 1885, 1 spec., BM(NH); H. Cuming, 1 spec., (NMV); 1, of Barias, Italy (?) H. Cuming, 1 spec., BM(NH).

REMARKS: *Clavagella (Bryopa) melitensis* is distinguished from all other species of *Bryopa* by the presence of prominent longitudinal ribs, 8 to 16 in number, on the tube. The presence of two species of the same subgenus, *C.(B.) aperta* and *C.(B.) melitensis*, with a similar distribution range is interesting. An understanding of possible ecological differences between the species will only emerge with further collecting and intensive study.

C. angulata, Philippi, 1844 and *C. laqueata*, Reeve, 1873, are included here in the synonymy of this species because, from the descriptions and figures of these species available, they fall within the species limits of this species.

Subgenus *Dacosta* Gray, 1858

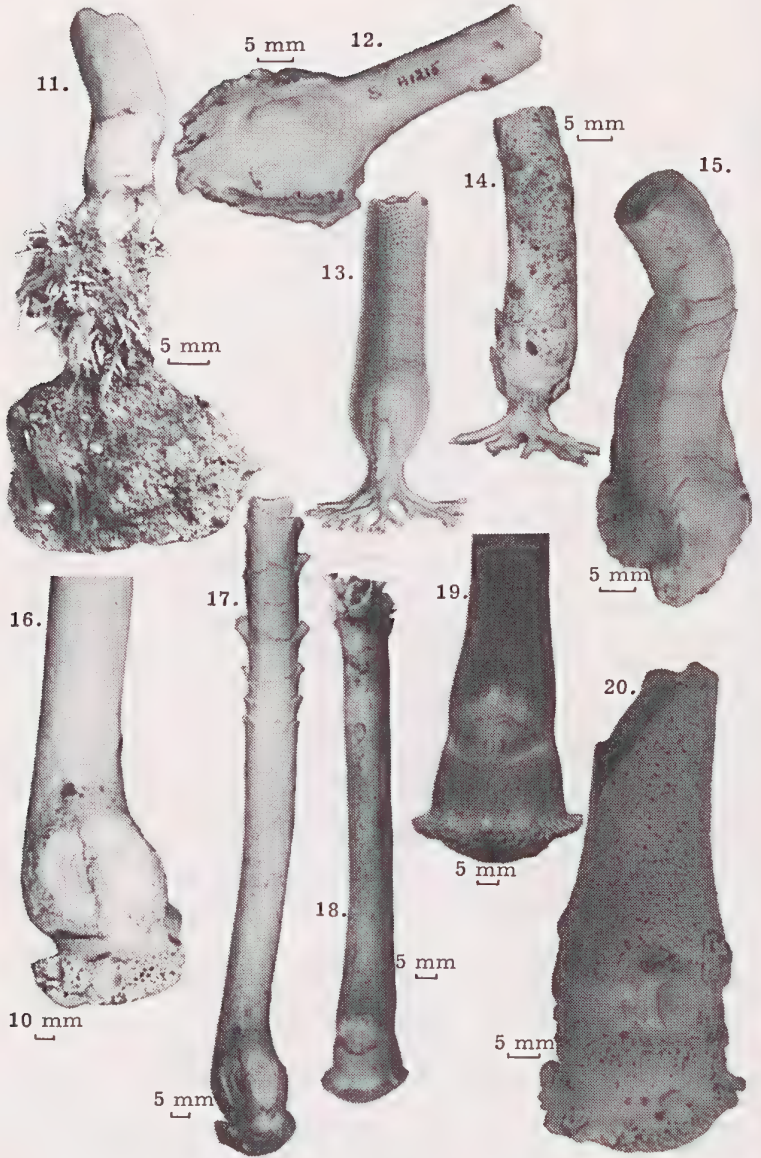
Dacosta Gray, 1858, *Proc. Zool. Soc. Lond.*, 26: 315. Type species: *Clavagella australis* Sowerby, 1829 (Monotypy).

Siphonal end simple, tube circular to ovoid in section, wide, with obvious growth rings. Anterior end attached to and embedded in rock or other hard substratum, with many short tubules around valve and anterior end. Free right valve circular to rectangular.

Clavagella (Dacosta) australis australis (Sowerby, 1829)

(Fig. 11)

Clavagella australis Sowerby, c. 1827-1829. *Stutchburg Catal. app.*: 3.



For synonymy see Smith (1971). *C. elongata* Broderip 1834 is now not considered to be a synonym of this species.

DIAGNOSIS: Siphonal end simple, tube circular in section with obvious growth rings. Valves large with free right valve circular to ovoid. Anterior chamber enlarged with tubules mainly confined to anterior end.

For details of type material and distribution see Smith (1971) and Map 1.

REMARKS: Since the revision of the species by Smith (1971), a very similar species was described from South Africa by Kilburn (1974) called *Clavagella (Clavagella) mullerae*. This is here considered to a subspecies of *C.(D.) australis*. The nominate subspecies differs from the South African form principally in the absence of longitudinal constrictions on the tube and in the shape of the free valve, being circular to ovoid instead of rectangular.

The Australian form is found with the anterior end only attached to and shallowly embedded in rock. However it is commonly covered in thick coralline algal growths which completely envelops the anterior chamber. I suspect that the South African specimen was also thus over-grown before it was cleaned by the collector. Cleaned specimens of the Australian form have a very similar form and appearance.

This nominate subspecies is confined to South-eastern Australia in mainly temperate to warm-temperate waters. The presence of a subspecifically related form from a general similar habitat in South Africa is of interest zoogeographically and will be discussed more fully below.

Clavagella (Dacosta) australis mullerae (Kilburn, 1974)

(Fig. 12)

Clavagella (Clavagella) mullerae, Kilburn, 1974. *J. de Conch.* 111(3-4): 89, figs. 1-4.

DIAGNOSIS: Siphonal tube elliptical, with a medium longitudinal constriction; body chamber large, set at an angle to tube; left valve covering most of chamber, fringed all around by a calcareous skirt edged with short, non-spinous, pliculiform tubules; valves almost rectangular, obliquely truncate posteriorly with the umbo towards the anterior; a distinct hinge with well developed teeth is present.

TYPE MATERIAL: Holotype in the Natal Museum, South Africa, NM A261. Dimensions: Right valve 23.3 x 13.4 mm; length of body chamber and "skirt" 30 mm; siphonal tube 28 mm in length, 9.2 x 5.6 mm. in cross-section; total height from base to tip of tube about 41 mm.

TYPE LOCALITY: South embankment, Durban Bay, South Africa, in hollow in sandstone.

DISTRIBUTION: Only known from the type locality.

REMARKS: This South African form is here considered a subspecies of *C.(D.) australis* because in general shape and structure it is very similar indeed. It differs only in the possession of longitudinal constrictions on the tube and in having a rectangular free valve instead of a circular to ovoid one. Kilburn (1974) placed this species in *Clavagella s.s.* because he probably assumed it was only attached by the anterior end. However a growth discontinuity can be seen where the tube emerged from the anterior chamber and it can be assumed that the specimen was embedded in rock or calcareous algae to this point. This fact of attachment associates it with the subgenus *Dacosta*. This subspecies is known only from the holotype.

Subgenus *Stirpulina* Stoliczka, 1870

Stirpulina Stoliczka, 1870. *Mem. Geol. Surv. India. Palaeont. Indica.*, 3: 27. Type species *Clavagella coronata* Deshayes, 1824. (O.D.).

Synonymy: *Stirpuliniola* Kuroda & Habe, 1971, *The Sea Shells of Sagami Bay, Tokyo*: 481. Type species *Clavagella ramosa* Dunker, 1882. (O.D.).

Figures 11-20.

11. *Clavagella (Dacosta) australis australis*, Sydney Harbour, N.S.W. (AM).
12. *Clavagella (Dacosta) australis mullerae*, holotype N.M. A261. Durban Bay, South Africa.
13. *Clavagella (Stirpulina) ramosa*, plate 16, figure 1 from Dunker 1882 *Index. Moll. Mar. Japan*.
14. *Clavagella (Stirpulina) ramosa*, Japan (NMV).
15. *Humphreyia (Humphreyia) strangei*, lectotype, BM(NH) 1968667 Sydney Harbour, N.S.W.
- 16-17. *Humphreyia (Nipponclava) gigantea*, holotype, BM(NH) 88.6.1.1. Japan.
18. *Brechites (Brechites) vaginiferus vaginiferus*, holotype, MNG Red Sea.
19. *Brechites (Brechites) vaginiferus vaginiferus*, anterior end of holotype of *A. delessertianum*, BM(NH) 197636.
20. *Brechites (Brechites) vaginiferus australis*, anterior end of syntype of *A. incertum*, BM(NH) 1968669, Swan River, Western Australia.

Tube long, siphonal end circular in section, simple or expanded into series of plaited ruffles; series of branching tubules at anterior end, with distinct central slit, not attached to substratum.

Kuroda and Habe (1971) considered a new genus was necessary for the species *C. ramosa* because of the presence of plaited ruffles in *C. coronata*, the type species of *Stirpulina* and not in *C. ramosa*. However many of the specimens of *C. ramosa* in collections have the siphonal end of the tube broken and it is uncertain that no plaited ruffles exist in complete specimens. However, it is felt that the presence or absence of plaited ruffles is not necessarily a generic character and that the form of the tubules is of more importance. It is also felt that all these characters are of subgeneric rank only.

Clavagella (Stirpulina) ramosa Dunker, 1882

(Figs. 13-14)

Clavagella ramosa, Dunker, 1882. *Index. Moll. Mar. Japan.* : 172, pl. 16, 1-2.

Clavagella (Stirpulina) ramosa, Hirase, 1934. *Coll. Jap. Shells* : 12, pl. 20, fig. 4.

Clavagella (Stirpulina) ramosa, Habe, 1952. *Ill. Cat. Jap. Shells*, 18: 122, pl. 18, fig. 19.

Clavagella (Stirpulina) ramosa, Skikoma, 1954. *Sci. Rep. Yokohama natn. Univ. Sec. II, No. 3.*: 64.

Stirpuliniola ramosa, Kuroda and Habe 1971. *The Sea Shells of Sagami Bay, Tokyo*: 481.

DIAGNOSIS: Tube long with practically no anterior swollen chamber, fused valve embedded in wall of tube; siphonal end circular in section, may possibly be expanded in a series of plaited ruffles; anterior end constricted anterior to valves then extended into a series of wide long branching tubules, with distinct central slit; not attached to hard substratum.

TYPE MATERIAL: No type material could be located after a search of all the museums likely to have held the type. However the illustration in Dunker together with later illustrations and specimens are sufficient to establish the species without the necessity of erecting a neotype.

TYPE LOCALITY: The original description gives "Near Japan at Hama Koorhama mo-men". Habe 1952 gives the type locality as Wakayama, Honshu, Japan.

DISTRIBUTION: (Map 1.) Sagami Bay and surrounding area, Honshu, Japan.

MATERIAL EXAMINED: Sagami Bay, 3 spec., (MCZ); 80 fms. (146 m); 2 spec., (MCZ); A. R. Cohn, 4 spec., (PAS); Misak, Tokyo Bay, 50-85 fms (91-155 m), 1 spec., (MCZ); Japan, E. B. & J. A. Grigg Colln., 2 spec., (NMV).

REMARKS: This is the only known living species in the subgenus, and is easily distinguished from all other clavagellids by the long, thick, branching tubules at the anterior end appearing to arise directly from the end of the tube.

Nothing is known of the anatomy of this animal but from the structure of the shell it appears to be most similar in life-style to many of the *Brechites* species.

Genus *Humphreyia* Gray, 1858

Humphreyia Gray, 1858. *Proc. Zool. Soc. Lond.*, 26: 317. Type species: *Aspergillum strangei* A. Adams, 1852 (Monotypy).

Valves large, both tused to tube in a single plate forming most of anterior bag-like cavity, tube round to angular in section, siphonal and simple or with plaited ruffles, anterior end with short tubules without organisation into fringe or disc; vestige of posterior adductor muscle persistent in the adults.

Subgenus *Humphreyia* s.s.

Shell small to medium, siphonal end simple, tube angular in section, usually attached to hard substrate by anterior end.

Humphreyia (Humphreyia) strangei (A. Adams, 1852)

(Fig. 15)

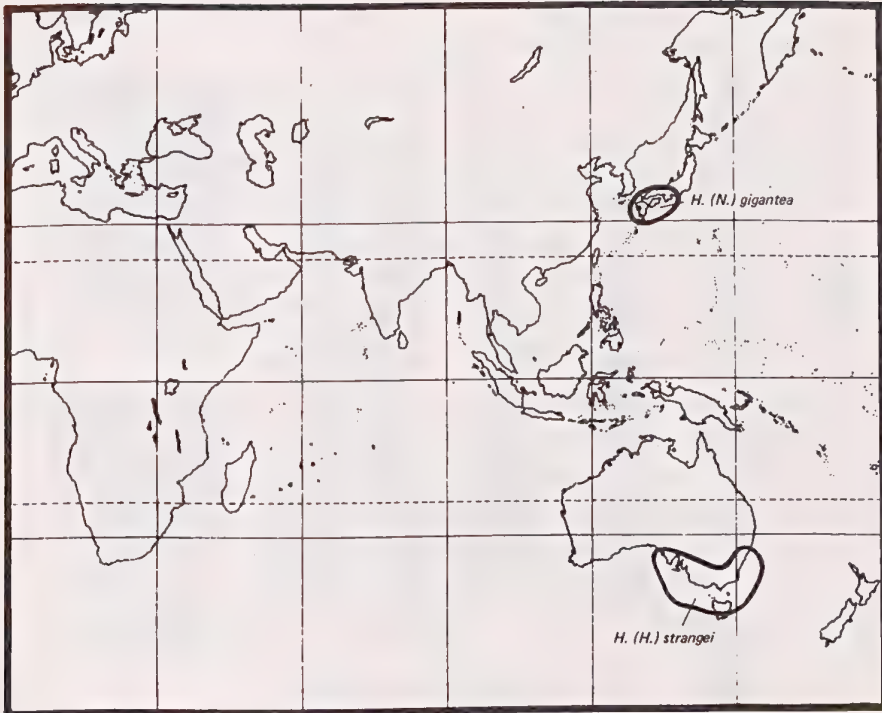
Aspergillum strangei, Adams, 1852. *Proc. Zool. Soc. Lond.*, 20: 91, pl. 15, fig. 5.

For synonymy see Smith (1971).

DIAGNOSIS: Shell medium to small, tube angular to square in section, siphonal end simple, no constriction between anterior chamber and tube, tubules short, confined to anterior end, valves large with calcareous protruberances of tube between them.

For details of type material and distribution see Smith (1971) and Map 2.

REMARKS: This species is characterized by the angular tube, sometimes being almost square in section, and the two large valves making up one side of the anterior chamber. Specimens are mainly found attached to hard substrata such as rocks or large dead shells by an expanded anterior end.



Map 2. Distribution map of recent species of the genus *Humphreyia* s.l.

In this case the anterior tubules are often arranged around the edge of the attached surface giving the appearance of root-like structures. In specimens which have probably not been attached, the tubules on the anterior end are evenly distributed, but with no regular pattern.

This species is confined to the cool temperate to warm temperate waters of southern and south-eastern Australia.

Subgenus *Nipponoclava* subgen. nov.

Type species: *Aspergillum giganteum* Sowerby, 1888.

Tube long, circular to ovoid in section, siphonal end with plaited ruffles; valves large, forming one side of swollen anterior chamber, calcareous protruberances extending down hinge-line between valves, anterior end with many rows of short wide tubules, without disc or fringe formed.

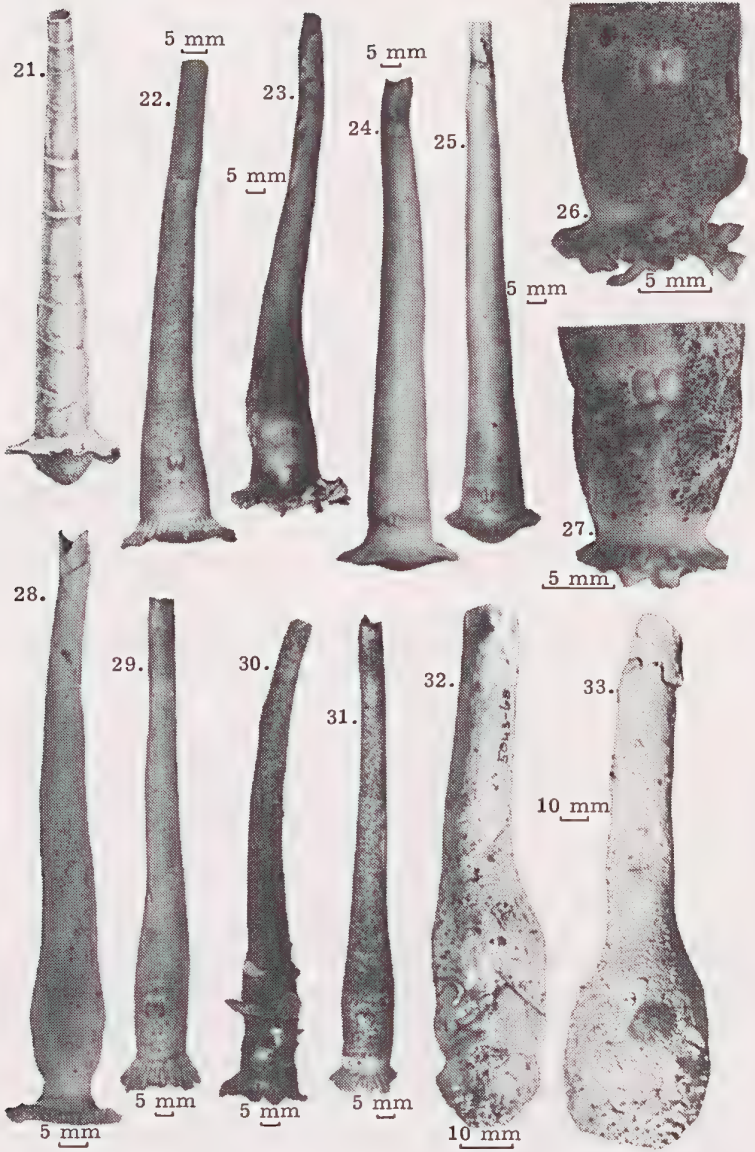
This subgenus is introduced to accommodate a second species of clavagellid having large valves, both of which are fused to the tube, forming a considerable part of the wall of the swollen anterior chamber. The view is taken that, in this family, the basic size and form of the valves is of primary taxonomic importance and that the presence of this character in *A. giganteum* Sowerby 1888 allies it with *Humphreyia* Gray 1858 and separates it from *Brechites* Guettard, 1770, which is characterized by very small valves. However *A. giganteum* has to be separated from *Humphreyia* s.s. because of the gross differences in tube shape and structure.

Humphreyia (*Nipponoclava*) *gigantea* Sowerby, 1888

(Fig. 16-17)

Aspergillum giganteum Sowerby, 1888. *Proc. Zool. Soc. Lond.* for 1888: 290.

Brechites giganteus. Normura 1933. *Sci. Rep. Tahoku Imp. Univ.*, (2) 16 (1): 65.



Brechites (Warnea) giganteus Kuroda 1947. *Ill. Encycl. Fauna Japan* : 1204, fig. 3417.

Penicillus (Warnea) giganteus Habe 1952. *Ill. Cat. Jap. Shells*, No. 18: 122, pl. 18, fig. 10.

DIAGNOSIS: As for subgenus above.

TYPE MATERIAL: Holotype in the British Museum, BM(NH) 88 6 1.1. Dimensions: Length 348 mm; External length of fused valves 31 mm.

TYPE LOCALITY: The original description gives the type locality as Japan. This is here restricted to Southern Honshu and Shikoku, Japan.

DISTRIBUTION: (Map 2.) The southern part of Honshu, Shikoku and Kyushu, Japan.

MATERIAL EXAMINED: Holotype from Japan; Boshu, Japan, C. T. Trechmann Colln., 1 spec., BM(NH); Tuteyoma, Tokyo Bay, Japan, 1 spec., (MCZ); Bosin, Japan, 1 spec., (MCZ); Tosa, Japan 35 fms (64 m), A. R. Cain, 3 spec., (PAS).

REMARKS: This species is characterized by the two large valves fused to the tube, by the long tube, circular in section, with the siphonal end extended in a series of plaited ruffles. The species is referred to the genus *Humphreyia* because of the size of the valves, being much larger and of a different form to those seen in *Brechites*.

Genus *Brechites* Guettard, 1770

Brechites Guettard, 1770, *Mem. diff. Sci.*, 3: 154. Type species *Aspergillum vaginiferum* Lamarck, 1818. (S.D.: Stolizcka, 1871).

Synonymy: *Verpa* Roding, 1798, *Mus. Bolten.* 2: 69. Type: *Serpula penis* Linne (Monotype).

Aquaria Perry, 1811, *Conchology*, pl. 52. Type: (none found).

Arytena Oken, 1815, *Lehrb. Nat.* 3 (1), XIV: 379 (rejected ICZN 1956).

Clepsydra Schumacher, 1817, *Ess. Vers. Test.*, 79: 261.

Aspergillum Lamarck, 1818, *H. N. Anim. sans. Vert.*, 5: 429.

Warnea Gray, 1858, *Proc. Zool. Soc. Lond.*, 26: 310.

Both valves fused with tube, valves small, tube circular in section.

Remarks on the synonymy are given in Smith (1971).

The genus is confined to the Indo-Pacific region and mainly to tropical seas only extending into the warm temperate to temperate waters of Southern Australia.

Subgenus *Brechites* s.s.

Synonymy: *Warnea* Gray, 1858.

Siphonal end with a series of plaited ruffles, disc fringe often indistinct, of a series of thick tubules, valves depressed and exposed.

Brechites (Brechites) vaginiferus vaginiferus (Lamarck, 1818)

(Fig. 18-19)

Aquaria imbricata Perry, 1811. *Conchology*, pl. 52, fig. 4, (*nomen oblitum*)

Aspergillum vaginiferum, Lamarck, 1818. *H. N. Anim. Sans. Vert.*, 5: 430.

Aspergillum vaginiferum, Chenu, 1843. *Illus. Conch.*, 1, *Aspergillum* : 2, pl. 1, figs. 1a, b, c, pl. 4, figs. 9a, b, c, pl. 5, figs. 1 & 9.

Aspergillum delessertianum, Chenu, 1843. *Illus. Conch.*, 1, *Aspergillum*: 3, pl. 1, figs. 2, 2a.

Figures 21-33.

21. *Brechites (Penicillus) penis*, plate 7, figure G from Argenville 1742, *L'Histoire Naturelle éclaircie dans deux de ses parties principales, la Lithogies et la Conchyliologie*, Paris.
22. *Brechites (Penicillus) penis*, holotype of *A. dichotomum* BM(NH) 197639, Red Sea.
23. *Brechites (Penicillus) penis*, syntype of *A. dijunctum* BM(NH) 197644.
24. *Brechites (Penicillus) penis*, syntype of *A. annulus* BM(NH) 197643, Singapore.
25. *Brechites (Penicillus) penis*, specimen figured in Chenu 1843 *Illus. Conch.* pl. 2, fig. 1. as *A. javanum* from Delessert Colln. Indian Ocean. (MNG).
26. *Brechites (Penicillus) philippinensis*, holotype, BM(NH) 197637, Saint Nicolas, Isle of Zebu, Philippines.
27. *Brechites (Penicillus) philippinensis*, holotype of *A. zebuense*, BM(NH) 197638, Isle of Zebu, Philippines.
28. *Brechites (Penicillus) philippinensis*, holotype of *A. strangulatum* BM(NH) 1841 10.12.38, Port Essington, (Northern Territory).
29. *Brechites (Penicillus) philippinensis*, holotype of *A. tuberculatum* (MNG), Moluques.
30. *Brechites (Penicillus) philippinensis*, holotype of *A. recluzianum*, BM(NH) 197641.
31. *Brechites (Penicillus) philippinensis*, syntype of *A. clavatum*, BM(NH) 197640.
32. *Brechites (Foegia) nouaezelandiae*, Cockburn Sound, Western Australia (WAM).
33. *Brechites (Foegia) veitchi*, holotype NMV F27419 off Cape Donnington, Port Lincoln, South Australia.

Warnea vaginifera, Gray, 1858. *Proc. Zool. Soc. Lond.*, 26: 309.
Aspergillum vaginiferum, Reeve, 1860. *Conch. Icon.*, 12, *Aspergillum*, pl. 1, fig. 2.
Aspergillum delessertianum, Reeve, 1860. *Conch. Icon.* 12, *Aspergillum* pl. 2, fig. 6.
Brechites vaginiferus, Stolzicka, 1870. *Mem. Geol. Surv. India. Palaeont. Indica*, 3: 28.
Penicillus (Warnea) vaginiferum, Smith, 1962. *Veliger*, 4(4): 174.

DIAGNOSIS: Shell large with long tube, circular in section with series of plaited ruffles, valves small in wide depression, anterior chamber only slightly wider than tube, tapering outwards to disc; disc large with short fringe of wide tubules, central area of disc with scattered perforations and central slit.

TYPE MATERIAL: Holotype of *Aspergillum vaginiferum* Lamarck is in the Museum d'Histoire Naturelle, Geneva, Switzerland. Dimensions: Length 218 mm; width of disc 35 mm. Holotype of *Aspergillum delessertianum* Chenu in the British Museum (Natural History), BM(NH) 197636. Dimensions: Length 300 mm; width of disc 41 mm.

No type specimen could be found of *Aquaria imbricata* Perry.

TYPE LOCALITY: The original type locality is given as Red Sea. This is here restricted to the Aden area.

DISTRIBUTION: (Map 3.) The whole of the Red Sea and Gulf of Aden, south down the east coast of Africa to off Zanzibar and north-east to the mouth of the Gulf of Oman.

MATERIAL EXAMINED: Red Sea. E. C. Freeman, 3 spec., BM(NH); C. T. Trechmann, 1 spec., BM(NH); H. Cuming, 4 spec., BM(NH); Miss Narne, 5 spec., BM(NH); Gabriel Colln. 1 spec., (NMV); H. Cuming, 2 spec., (NMV); Kurran, N. of Muscat, Oman, A. J. Read, Dec. 1963, 1 spec., BM(NH); Aden, H. C. Dinshaw, 1 spec., BM(NH); Suez Flats, Comb. Univ. Exped. Suez Canal, 1924, 1 spec., BM(NH); Suez Bay, J. K. Kord, 1 spec., BM(NH); 4 km W. Chargo Is., West Zanzibar, 15 fms (27 m), Thorington St. 659, 3 spec., (PAS); 3 km N. Pupic Is., N. W. Zanzibar 7-9 fms (13-17 m), Thorington St. 650, 1 spec., (PAS); Between Mwamba Akombi and Chunbe Is., S. W. Zanzibar 4-6 fms (7-11 m), 2 spec., (PAS); Chunbe Is., S. W. Zanzibar, 1 spec., (PAS); Aden; W. H. Dall, 2 spec., (USNM); Zanzibar Is., H. Makame, March 1959, 1 spec., (USNM).

REMARKS: Only slight differences are recognisable between *B.(B.) vaginiferus* from the Red Sea and W. Indian Ocean and *B.(B.) australe* from Western Australia and these two forms are here given subspecific rank of the senior species *A. vaginiferum* Lamarck, 1818. The nominate subspecies differs from the Australian form in having the anterior end of the shell, between the valves and the disc, tapering outwards to the disc, giving the anterior chamber a triangular appearance. The tube of the nominate subspecies is narrower and finer in structure than the Australian form. The Australian subspecies has a straight-sided anterior chamber with a slight constriction just posterior to the disc. It is also a broader, more solid shell.

Aquarius imbricata, Perry, 1811, is here referred to as a *nomen oblitum* for although, from the figure, it is similar to this species, both the figure and the description are considered insufficient, in the absence of type material, to refer it to a particular species with certainty.

A. delessertianum is considered a synonym as it falls within the species limits of this subspecies.

The nominate subspecies is confined to the north-eastern part of the Indian Ocean. This is considered a true picture of its distribution as it is such a large shell it is thought it would have been recorded if it had been more widespread.

Brechites (Brechites) vaginiferus australis (Chenu, 1843)

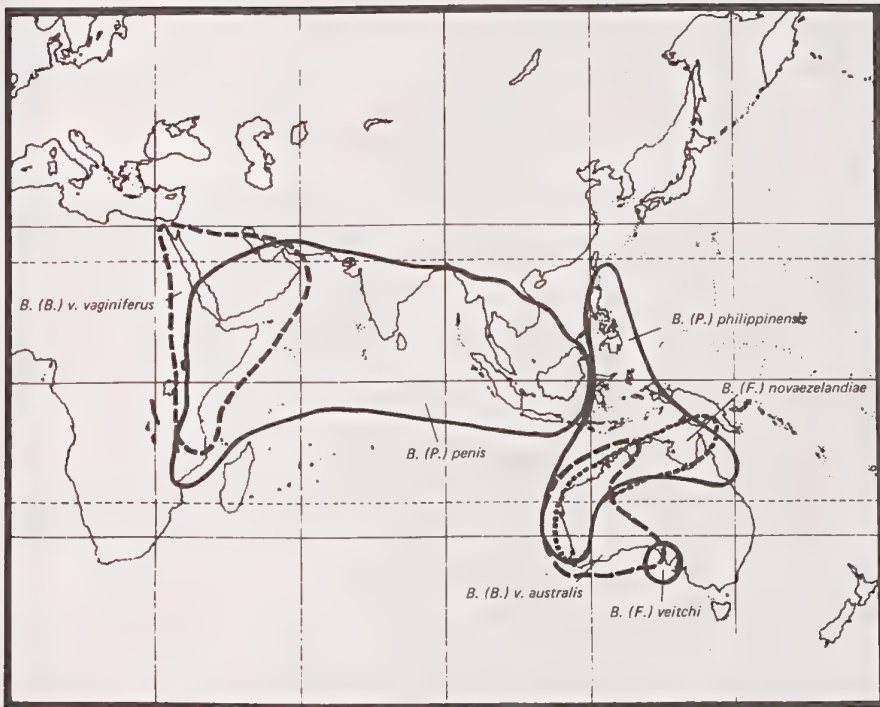
(Fig. 20)

Aspergillum australe, Chenu, 1843. *Illus. Conch.*, 1, *Aspergillum*, 3, pl. 3, figs. 1, 1a.
 For synonymy see Smith (1971).

DIAGNOSIS: Shell large with long tube, circular in section with plaited ruffles, valves small in wide depression, anterior chamber enlarged with straight sides and a slight constriction immediately behind disc; disc large with short fringe of wide tubules and central slit.

TYPE MATERIAL: The type specimen of *A. australe* could not be found in a search of the British Museum (Natural History) and other institutions. Holotype of *A. cumingianum* is in the British Museum, BM(NH) 19718 and two syntypes of *A. incertum*, BM(NH) 1968669/70.

TYPE LOCALITY: The type localities for *A. australis* and *A. cumingianum* are given as Australian seas while that for *A. incertum* is given as Swan River, New Zealand. This is certainly a mistake for Western Australia. The type locality is here restricted to the Barrow Is., Roebourne, Dampier area of North Western Australia.



Map 3. Distribution map of the recent species and subspecies of the genus *Brechites* s.l.

For details of distribution and material examined see Smith (1971) and Map 3.

REMARKS: The Australian form is here restricted to a subspecies of *B. (B.) vaginiferus* from the Red Sea and is differentiated from it by its heavy, more solid shell and the squarer shape of the anterior chamber brought about by the presence of a slight constriction immediately behind the disc. The occurrence of these very closely related subspecies at opposite sides of the Indian Ocean is readily understandable zoogeographically and will be discussed below.

Subgenus *Penicillus* Bruguiere, 1789

Penicillus Bruguiere, 1789, *Ency. Method. (Vers)*. 1: 126. Type species: *Serpula aquaria* Burrow, 1815 = *Serpula penis*, Linnaeus, 1758: (S.D. — Stolizcka, 1871).

Synonymy: *Cleypsydra* Schumacher, 1817.

Siphonal end of tube simple, disc fringed with single row of tubules, umbos exposed but valves not depressed and exposed.

Brechites (Penicillus) penis (Linnaeus, 1758)

(Fig. 21-25)

Serpula penis, Linnaeus, 1758, *Syst. Nat.* 6: 3744

Penicillus javanus, Bruguiere 1789, *Ency. Method. (Vers)*, 1: 128.

Aquaria radiatus, Perry, 1811, *Conchology*, pl. 52, fig. 3.

Aspergillum sparsum, Sowerby, 1823, *Genera of Recent and Fossil Shells*, 27, figs. 3, 5.

Aspergillum javanum, Chenu, 1843, *Illus. Conch.*, 1, *Aspergillum* : 2, pl. 2, figs. 1, 1a, b, c, 2, 2a, 5, 5a

Aspergillum dichotomum, Chenu, 1843, *Illus. Conch.*, 1, *Aspergillum* : 3, pl. 2, figs. 6, 6a.

Aspergillum semifimbriatum, Chenu, 1843, *Illus. Conch.*, 1, *Aspergillum* : 4, pl. 3, figs. 5, 5a.

Aspergillum listeri, Gray, 1858, *Proc. Zool. Soc. Lond.*, 26: 311.

Aspergillum pulchellum, Gray, 1858, *Proc. Zool. Soc. Lond.*, 26: 311.

- Aspergillum annulus*, Gray, 1858, *Proc. Zool. Soc. Lond.*, 26: 312.
Aspergillum pulchrum, Gray, 1858, *Proc. Zool. Soc. Lond.*, 26: 312.
Penicillus aquaria, Gray, 1858, *Proc. Zool. Soc. Lond.*, 26: 312.
Aspergillum annulosum, Reeve, 1860, *Conch. Icon.*, 12, *Aspergillum*, pl. 1, figs. 1a, b.
Aspergillum javanum, Reeve, 1860, *Conch. Icon.*, 12, *Aspergillum*, pl. 1, fig. 3.
Aspergillum semifimbriatum, Reeve, 1860, *Conch. Icon.*, 12, *Aspergillum*, pl. 2, fig. 5.
Aspergillum dichotomum, Reeve, 1860, *Conch. Icon.*, 12, *Aspergillum*, pl. 3, fig. 9.
Aspergillum disjunctum, Reeve, 1860, *Conch. Icon.*, 12, *Aspergillum*, pl. 3, fig. 12.
Aspergillum pulchrum, Reeve, 1860, *Conch. Icon.*, 12, *Aspergillum*, pl. 3, fig. 13.
Brechites penis, Purchon, 1956, *J. Linn. Soc.* 43: 43
Penicillus (Penicillus) penis, Smith 1962, *Veliger*, 4(4): 172.

DIAGNOSIS: Shell medium to large, fragile, with long tapering tube, siphonal end simple, circular, oval to figure 8 in section; anterior end not swollen, no constriction between valves and disc, taper of tube continued to disc; disc with delicate fringe of long fine tubules, central part of disc raised hemispherical to almost flat, with fine perforations and central slit.

TYPE MATERIAL: No type specimen of *Serpula penis* can be found. Linnaeus in the original description refers to a figure in Argenville (1742) – plate 7, fig. G. No types could be located from *P. javanum* Bruguiere, 1789, *A. radiatus* Perry, 1811, *A. listeri* Gray, 1858, *P. aquaria* Gray, 1858 or *A. pulchrum* Reeve, 1860. Types of the other four synonyms are in the British Museum. *A. dichotomum* Chenu 1843, BM(NH) 197639; *A. semifimbriatum* Chenu, 1843, BM(NH) 197642; *A. disjunctum* Reeve, 1860, BM(NH) 197644; *A. annulus* Gray, 1858, BM(NH) 197643 – this is a Deshayes manuscript name and *A. annulosum* Reeve 1860 is a junior objective synonym based on the same specimen (S. Whybrow pers. comm.).

TYPE LOCALITY: The Indian Ocean is the type locality of the many synonyms, from Java to the Red Sea. The type locality is here restricted to Singapore.

DISTRIBUTION: (Map 3.) From a western limit of North Borneo, Amboina and Java, to Burma, Ceylon, to the west coast of Africa south to Mozambique.

MATERIAL EXAMINED: Singapore. C. T. Trechmann, 1 spec., BM(NH); Miss Archer, 3 spec., BM(NH); H. Cuming, 3 spec., BM(NH); 4 spec., (MCZ); Gabriel Colln., 2 spec., (NMV); H. Cuming, 2 spec., (NMV). 91 km S. of Chittagong, 22 m (21° 00' N, 91° 59' E) Anton Bruun April 1963, 2 spec., (PAS); 12 km N.W. Port Blair, S. Andoman Is. 90 m (11° 49' N, 92° 53' E), A. Bruun, March 1963, 2 spec., (PAS); 60 km W. Tavay Is., South Burma, 68 m (13° 00' N, 97° 41' N), A. Bruun, 1 spec., (PAS); 100 km N.W. Tavay Is. Burma 39 m (13° 28' N, 97° 19' E), A. Bruun, 1 spec., (PAS); Changi, Singapore, R. D. Purchon, 1 spec., (PAS); Bedok, Singapore, LWNT, R. D. Purchon, 1 spec., (PAS); Java, J. Williamson, 4 spec., BM(NH); H. Cuming, 3 spec., BM(NH); H. Cuming, 2 spec., (NMV); Amboina, M. J. Landauer, 1870, 1 spec., (MNG); Berhabals Sandakon, North Borneo, Mary Saul 1963, 1 spec., (PAS); Tamjong Aru, N. Borneo, Mary Saul 16 Sept. 1961, 2 spec., (PAS), 4 spec., (USNM); 5 km E. Lighthouse Is., Pluket Is., Andaman Sea, Thailand, 80 ft (24 m) Abbott and Criden, Feb. 1963, 19 spec., (PAS); Banghert Bay, Gulf of Siam, H. M. Smith, 13 July, 1926, 1 spec., USNM, China, G. Tradercant, 1 spec., BM(NH); Ceylon, Dr. Gardinum 2 spec., BM(NH); Maldine Is., 1 spec., (NMV); Red Sea, 1 spec., BM(NH); Tuticornin, R. Winckworth, 3 spec., BM(NH); 2 km E. Pange Is., W. Zanzibar, 10 fms (18 m), Jan 1957, 1 spec., (PAS); Wasia, Kenya, J. D. Taylor, 18 Nov. 1971, 1 spec., BM(NH); Shimoni, Kenya, J. D. Taylor, 3 spec., BM(NH). Mozambique, 3 spec., BM(NH); Belcher Coll., 5 spec., BM(NH).

REMARKS: This and the following species are the most commonly collected watering-pot shells and because of their unusual structure were a popular part of early collectors cabinets. This fact, coupled with the high level of individual variation in the shape and form of the shells and the view of species by the early conchologists, inevitably resulted in a proliferation of species names in the literature. A relatively large number of specimens belonging to the subgenus *Penicillus*, being long delicate tapering shells with a fine fringe of tubules around an even disc, were available for this study, including many of the types of the various species. It was finally decided that these could be separated into two groups on shell features and these are given here as two species.

Brechites (Penicillus) penis is characterized by the anterior part of the tube, between the valves and the disc, continuing to taper outwards towards the anterior end, with no constriction present behind the disc. A great deal of minor variation occurs with the shape and form of the disc, ranging from a flat to an almost hemispherical or hemi-elliptical central region as in the form called *A. javanum*, and with disc fringes ranging from short coarse tubes to fine long almost fused tubules. However these are all considered as intraspecific variation and intermediate forms between these extremes are present in

the material examined. All the species listed as synonyms fall within the limits of the species as defined.

The distribution of the species extends throughout the tropical part of the Indian Ocean from West Africa to Borneo, eastward of which it is replaced by *B. (P.) philippinensis*. Gaps in the distribution given from specimens examined can be filled in for South India from Hornell (1921), Madras from Gravelly, 1941 and Pombon, Krusadai Island from Satyamurti (1956).

Brechites (Penicillus) philippinensis (Chenu, 1843)

(Fig. 26-31)

- Aspergillum philippinense*, Chenu, 1843, *Illus. Conch.*, 1, *Aspergillum* : 3, pl. 4, figs. 7, 7a.
Aspergillum zebuense, Chenu, 1843, *Illus. Conch.*, 1, *Aspergillum* : 3, pl. 3, figs. 3, 3a.
Aspergillum tuberculatum, Chenu, 1843, *Illus. Conch.*, 1, *Aspergillum* : 3, pl. 2, figs. 3, 3a, b, c.
Aspergillum strangulatum, Chenu, 1843, *Illus. Conch.*, 1, *Aspergillum* : 3, pl. 2, figs. 4, 4a.
Aspergillum ornatum, Chenu, 1843, *Illus. Conch.*, 1, *Aspergillum* : 4, pl. 4, figs. 3, 3a.
Aspergillum clavatum, Chenu, 1843, *Illus. Conch.*, 1, *Aspergillum* : 4, pl. 4, figs. 4, 4a.
Aspergillum reclusianum, Chenu, 1843, *Illus. Conch.*, 1, *Aspergillum* : 4, pl. 4, figs. 1, 1a.
Aspergillum incrassatum, Chenu, 1843, *Illus. Conch.*, 1, *Aspergillum* : 4, pl. 4, figs. 2, 2a, b.
Penicillus radix, Gray, 1858, *Proc. Zool. Soc. Lond.*, 26 : 312.
Clepsydra strangulata, Gray, 1858, *Proc. Zool. Soc. Lond.*, 26 : 313.
Arytene tuberculatum, Gray, 1858, *Proc. Zool. Soc. Lond.*, 26 : 313.
Aspergillum zebuense, Reeve, 1860, *Conch. Icon.*, 12, *Aspergillum*, pl. 3, fig. 8.
Aspergillum philippinense, Reeve, 1860, *Conch. Icon.*, 12, *Aspergillum*, pl. 3, fig. 10.
Aspergillum radix, Reeve, 1860, *Conch. Icon.*, 12, *Aspergillum*, pl. 3, fig. 11.
Aspergillum clavatum, Reeve, 1860, *Conch. Icon.*, 12, *Aspergillum*, pl. 4, fig. 14.
Aspergillum incrassatum, Reeve, 1860, *Conch. Icon.*, 12, *Aspergillum*, pl. 4, fig. 15.
Aspergillum tuberculatum, Reeve, 1860, *Conch. Icon.*, 12, *Aspergillum*, pl. 4, fig. 16.
Brechites (Penicillus) strangulatus, Smith, 1971, *J. Malac. Soc. Aust.* 2(2): 151.

DIAGNOSIS: Shell medium to large, fragile with long tapering tube, siphonal end simple, circular to figure 8 in section; anterior end slightly swollen with constriction in tube immediately behind the disc; disc with fringe of fine regular tubules, central area flat to raised, perforated, with central slit.

TYPE MATERIAL: Holotype of *A. philippinense* is in the British Museum, BM(NH) 197637. Dimensions: Length 90 mm.

The details of the species considered here as synonyms are:—*A. zebuense*, Chenu, 1843, holotype, BM(NH) 197638; *A. tuberculatum* Chenu, 1843, holotype, (M.N.G.); *A. strangulatum*, Chenu, 1843, holotype, BM(NH) 1841.10.12.38; *A. clavatum*, Chenu, 1843, 3 syntypes, BM(NH) 197640; *A. reclusianum* Chenu, 1843, holotype, BM(NH) 197641; *A. incrassatum*, Chenu, 1843, holotype, (M.N.G.). The types of *A. ornatum*, Chenu, 1843 and *P. radix*, Gray, 1858 could not be found.

TYPE LOCALITY: The original description of *A. philippinense* gives the type locality as Saint Nicolas, Island of Zebu, Philippines. The type localities of the various synonyms range from the Philippines to Northern Australia.

DISTRIBUTION: (Map 3.) From off Rottneest Island, Western Australia and Central Queensland, north through the Philippines to the China Sea.

MATERIAL EXAMINED: Australian material listed by Smith (1971). Types of all synonyms listed above. Amboina, H. Cuming, 3 spec., BM(NH); Gabriel Colln. 2 spec., (NMV); Moluccas, H. Cuming, 2 spec., (NMV); H. Cuming, 3 spec., BM(NH); China Sea, off Pratas Is. 88 fms (160 m), U.S.B. Fisk., 4 spec. (USNM); 100 fms (183 m) U.S.B. Fisk., 1 spec., (USNM); Philippines off S.E. Tawi Tawi 18 fms (33 m), U.S.B. Fisk., 1 spec., (USNM).

REMARKS: As stated for the previous species, the relegation to synonymy of the eight species names listed above was done after considering a relatively large number of specimens from throughout the range, including most of the types of these species. Smith (1971) used the name *B. (P.) strangulatus* for this species, but *B. (P.) philippinensis* must be used as it has page preference.

This species is characterized by the marked constriction in the tube immediately behind the disc fringe. The disc and disc fringe of tubules shows considerably intra-specific variation. Another variable character used by some workers as a species character is the presence of various forms of protruberances or growths of tube substance over the valves, in extreme cases practically covering the valves. This growth variation is very common and variable within the species.

The distribution of the species is within the island complexes of the Philippines, western Indonesia and tropical Australia, extending in a warm current in deep water down into what is usually thought of as the warm temperate part of Western Australia.

Subgenus *Foegia* Gray, 1847

Foegia Gray, 1847, *Proc. Zool. Soc. Lond.*, 15: 188. Type species *Aspergillum novaezelandiae* Lamarck, 1818 = *Penicillus novaezelandiae* Bruguere, 1789: (Monotype)

Siphonal end simple, disc often indistinct, without fringe, umbos usually almost covered with swollen prominences.

Brechites (Foegia) novaezelandiae (Bruguere, 1789)

(Fig. 32)

L'Arrosoire, de la Nouvelle Zelande. Favanne, 1780. *Conchyliogie* 1: 642, pl. 79, fig. E. (non. binom.) Type figure.

Penicillus novaezelandiae Bruguere, 1789. *Ency. Meth.*, 1: 129.

For synonym see Smith (1971)

DIAGNOSIS: Disc small, of a tight cluster of tubules, fringe absent, anterior portion only slightly bulbous, tapering to a narrow tube.

For details of types and distribution see Smith (1971) and Map 3.

REMARKS: Only a few specimens of this species are available, all from Australian waters, giving the species a warm-temperate to tropical distribution.

Brechites (Foegia) veitchi Smith, 1971

(Fig. 33)

Brechites (Foegia) veitchi, Smith, 1971. *J. Malac. Soc. Aust.*, 2(2): 154.

DIAGNOSIS: Shell large, anterior end greatly swollen, lacking a discrete disc; tubules covering bulbous portion except around valves; valves small, tending to become covered by swollen prominences, small anterior slit, small tube wide, circular in section, siphonal end simple.

For details of types and distribution see Smith (1971) and Map 3.

REMARKS: The only two species of this subgenus are confined to Australia and are known from only a comparatively small number of specimens. This species is confined to the cool temperate to temperate waters of South Australia and is easily recognised by its large size and enlarged, bulbous anterior portion of the shell. *B (F) novaezelandiae* is smaller, with the anterior portion only slightly swollen and has a warm temperate to tropical distribution.

DISCUSSION

The family Clavagellidae is a group of bivalves characterized by having either one or both of the valves fused into a shelly tube which is open at the posterior end to give access by the siphons to the exterior and with a closed, blind ending, anterior end perforated by many small holes extending externally into open tubules. The animals either bore or burrow into rock or coral, live attached to hard substrata or buried in sand. Only one or two species are found intertidally or immediately sublittorally, most being found in moderately deep water. Consequently the clavagellids are a rare group of animals (only sparsely represented in collections) with very few specimens being found alive. Most records consist of dead shells either dredged or washed up on beaches. Because of this rarity, coupled with the relative paucity of "good" anatomical species characters in bivalves, the criteria used in this revision are purely shell characters.

The Clavagellidae appeared to have been of interest to the early collectors because of their rarity and unusual, if not bizarre, form and several early works on the group (Chenu, 1843; Gray, 1858; Reeve, 1860 and 1873) emphasized the wide variation in the group and many new taxa resulted. However most of these descriptions utilized characters which are here considered of no specific value.

This work is confined to the recent species principally because of the wide range of representation in the fossil record, with one or two faunas being well represented while most others are almost unknown. However it is fully realized that the species living today represent the remnants of a once more abundant and diverse group. The view has been

taken in this work that generic and subgeneric groupings are reflected in the basic form and structure of the valves with secondary importance being given to the form of the anterior end of the tube and to the broad habitat preferences of the species. Specific groups within these higher taxa categories are made on general shell form. Thus three genera are recognized in the family, based on valve structure. *Clavagella* s.l. is characterized by having only one valve fused with the tube, the other being free inside the anterior chamber; *Humphreyia* s.l. and *Brechites* s.l. each have both valves fused to the tube. In the former the valves are large, while those of the latter are very small to vestigial. This apparent evolutionary sequence, away from a typically bivalve arrangement towards a simple tube, is probably only partially reflected by the fossil record. Smith (1962) confirms that the earliest known fossil clavagellids from the Upper Cretaceous belonged to *Clavagella* s.s. closely followed in geologic time by *Clavagella* (*Stirpulina*). These forms, thought to be the most primitive on palaeontological grounds, can also be considered the closest to the unspecialized bivalve stock from which it is assumed the clavagellids evolved. These two forms either live buried in the substrate or attached only by their anterior ends and have only one valve fused with the tube with both adductor muscles persistent in the adult. According to Smith (1962) these two groups possibly represent the ancestors of two separate lines of development, with *Clavagella* s.s. giving rise to the two groups of *Clavagella* s.l. which bore or otherwise inhabit hard substrata and to *Humphreyia* s.l., while *Clavagella* (*Stirpulina*) gave rise to *Brechites* s.l. Even allowing for collector artefact and bias, a certain amount of support for this view can be gained from consideration of the distribution of the recent species in the three genera.

The distribution of the nine recent species and subspecies in *Clavagella* s.l. (Map 1.) gives a scattered pattern of rare, restricted species with a somewhat peripheral distribution around the main Indo-Pacific region. It gives the impression of a series of remnant groups. This impression is reinforced by the fossil record of this group given by Smith (1962) together with evidence from Smith (1971) which gives the genus a very widespread distribution in the Upper Cretaceous to the Oligocene. The recent distribution of *Clavagella* s.s. being confined to Australia and the Malaysian-Indonesian Archipelago and of *Clavagella* (*Stirpulina*) to Japan could be interpreted as being peripheral remnants of a more general Tethyan fauna. The two very closely related populations of *Clavagella* (*Dacosta*) in the temperate to warm temperate waters of south eastern Australia and south eastern Africa are probably of more recent origin. The four species and subspecies of *Clavagella* (*Bryopa*) distributed more widely in the Mediterranean and Indian Ocean probably represent a later more specialized form of *Clavagella* s.l., the restricted distributions of the species being partly a collector artefact, the probable distributions being much wider.

The distribution of the two recent species of *Humphreyia* s.l. (Map 2.), being restricted to relatively small areas of temperate to cool temperate seas of the northern and southern hemispheres at the western extremities of the distribution of the family, represent two isolated species of a probable advanced evolutionary stage to *Clavagella* s.l. found outside the distribution range of the other main genus, *Brechites* s.l. now found widespread throughout the tropical Indo-Pacific. A possible hypothesis of relationships is that the species of *Humphreyia* s.l. now represent the remnants of a much more widespread colder water fauna, now contracted to north and south by warmer conditions and replaced by a possibly more advanced warmer water group. This will remain an

attractive hypothesis until other species referable to *Humphreyia* s.l. can be located in the fossil record. The placing of the new subgenus *Nipponoclava* and the large Japanese species *H.(N.) gigantea* into *Humphreyia* s.l., while justified on conchological grounds, will have to await full anatomical studies for confirmation.

Brechites s.l. is a widespread Indian Ocean group in distribution (Map 3.) with four of the six species and subspecies being found in Australian waters. It is a tropical to warm temperate group with only *Brechites (Foegia)* having a relatively restricted distribution. This group first appeared in the fossil record in the Oligocene and Lower Miocene, and, except for one aberrant group, *Brechites (Pseudobrechites)* from the Lower Miocene of Europe (Smith, 1962), the group has been found only in the Indian Ocean and western Pacific.

Unlike *Clavagella* s.l., *Humphreyia* s.l. and especially *Brechites* s.l. appear at present to be at their most widespread and diverse distribution. Even so, much more information and material is needed of this very unusual group of bivalves before further work can be done on interrelationships and biology of the group.

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LABORATORY REARING OF LARVAL *OSTREA ANGASI* IN TASMANIA, AUSTRALIA

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SUMMARY

Larval *Ostrea angasi* released from parents in the summer 1974/75 were about 190-200 μm in shell length. The darkly pigmented larvae formed rounded umbones during growth and the relationship between shell length (l) and width (w) was described by the G.M. regression: $w = 0.820 l + 13.010$. Eye-spots were common in those 270 μm long and spat began setting at about 300 μm when 12-20 days old at 17°C. Few pelagic larvae larger than 320 μm were observed. The provincial structure was simple and similar to other *Ostrea* species. Larval development differs from that in the closely related New Zealand mud oyster and provides further evidence to separate these species. Success rates varied between the 6 batches held in 901 culture containers but one batch yielded a significant spat catch on scallop shells which were kept in a recycling system before transfer to the sea. Circulation of the cultures with a vertical, central airlift appeared to enhance success.

INTRODUCTION

In the late 19th century the native or mud oyster, *Ostrea angasi* Sowerby provided a large dredge fishery and was farmed also in Tasmania (Sumner, 1972). With present emphasis on farming *Crassostrea gigas* in this State and with a non-existent dredge oyster fishery, the commercial importance of *O. angasi* has dwindled. This contrasts with the continuing and important dredge fishery for the closely related *O. lutaria* in southern New Zealand (Street and Crowther, 1973).

Despite its earlier commercial significance and also its wide distribution in southern Australian waters (Thomson, 1954), the biology of *O. angasi* is virtually unknown (Hodson, 1963; Sumner, 1972). My work with this species primarily aimed at a brief assessment of laboratory rearing methods being used with the commercial scallop, *Pecten meridionalis* (Dix, in prep., Dix and Sjardin, 1975). The present paper, however, is largely descriptive. It represents a contribution to the biology of *O. angasi* and descriptions of the pelagic larvae should assist future planktologists. In addition, the study confirms Hollis' (1963) belief that the Australian *O. angasi* and the New Zealand *O. lutaria* are distinct species.

MATERIAL AND METHODS

Present findings are based on six batches of larvae from five collections of adult oysters made in south-eastern Tasmania in January and February 1975 (Table 1).